INDUSTRIAL HYGIENE SECTION

This Industrial Hygiene Section is published to promote sound thought upon and concerning industrial hygiene. To that end it will contain articles, discussions, news items, reports, digests, and other presentations, together with editorial comments. The editorial policy is to encourage frank discussion. On this basis contributions are invited.

Industrial Medicine

Reg. U. S. Pat. Off.

The Editorial Committee will exercise its best judgment in selecting for publication the material which presents most exactly the factors affecting industrial health and developments for control of potentially injurious exposures. The editors may not concur in opinions expressed by the authors but will endeavor to assure authenticity of fact.

The Science, the Law and the Economics of Industrial Health

Volume 5 | April, 1944 | Section 2

Teamwork

ONE HEARS much about teamwork between the Army, Navy, and Air Force on the battle fronts. The importance of cooperation in military operations is evident from our successes in the South Pacific, in Africa, and in Italy. The field of industrial hygiene is another that requires a great deal of teamwork, because of the large number of professions that are making contributions to better health, better morale, and better production in industry.

That there is teamwork among the workers in this field is evident from the WAR CONFERENCE ON INDUSTRIAL HEALTH to be held in St. Louis during the week of May 8. Beginning with its first annual meeting, the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION has met jointly with the AMERICAN ASSOCIATION OF INDUSTRIAL PHYSICIANS AND SURGEONS. Last year the NATIONAL CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS met with us, and at St. Louis the AMERICAN ASSOCIATION OF INDUSTRIAL NURSES will also meet with us—making a total of four organizations convening jointly. This spirit of cooperation should be mutually beneficial to all of us. The contacts and acquaintances made at the meeting should be helpful in instituting and carrying out industrial hygiene programs in industry, and should encourage further cooperation among the various professions engaged in this field.

How about the attitude of those for whom this work is being done—labor and management? There are many indications that they are receptive to any contributions the industrial hygienist can make. This is a healthy condition, and one that should lead to complete cooperation of all interested parties.

These trends, fortunately, are not the result of the war, and therefore something to be discarded with the end of the war. They are a continuation of progress started during peacetime, and should continue without interruption after the war. There was no period of "conversion" for the industrial hygienist to enter the war program. With years of experience, trained personnel with the "know how" were able at a moment's notice to take over their new responsibilities. To go from plants manufacturing civilian goods to those producing military matériel was an easy step. The change-over from war to peace should also be easy for the industrial hygienist. However, this ease of shifting from war plants to plants producing civilian goods should not cause the industrial hygienist to overlook some excellent opportunities. Reconversion of industry to produce civilian goods will require many and major changes in plants and equipment. The industrial hygienist should be on the job and alert to the possibility of having his ideas for better working conditions incorporated when other changes are being contemplated. It is easier to change a blueprint than finished buildings or equipment.

These changes are in the future—how far we do not know—so at present our all-out efforts shall be to keep up production. The industrial hygienists have demonstrated the importance of their contributions to a world at war. When the time comes, let us demonstrate that we can make even greater contributions to a world at peace.

—H. H. SCHRENK, President,
American Industrial Hygiene Association.

Differences in Points of View

IN THE formulation of viewpoints concerning industrial health hazards and methods of their correction, differences of opinion develop depending upon the nature of the problem and the local conditions which have entered into the experience of separate investigators. In order to bring out a more complete picture of any situation, particularly where there may be some controversial aspects to it, communications to the editor concerning papers appearing in this publication are welcome. Elsewhere in this issue is a discussion concerning the relative emphasis which should be placed on ingested and inhaled radium in connection with radium painting operations discussed in the December, 1943, issue. It is just such discussions as this which permit formulation of well-balanced points of view and more effective control of industrial health hazards.

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Industrial Hygiene Problems

—in the Synthetic Rubber Industry—

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BECAUSE the industry is relatively new in the United States there is much work to be done in evaluating and controlling the health hazards peculiar to the production and use of synthetic rubber. Control will be considered from an engineering approach only. Wherever possible, unsolved problems, which may be studied most effectively by those engaged in this industry, will be indicated. These studies should aim at the control of health hazards now as well as in postwar production of synthetic rubber. The economic value of industrial disease prevention has been emphasized by S. C. Sufrin, of the Rubber Products Branch of the War Production Board[3]:

"As an economist, I would like to point out that if the laboring people discover that certain jobs, although paying fairly good wages, cause the workers to become ill, the job opportunities are so great that those people leave and go to other jobs, which means a long breaking-in period with attendant interruptions to production. I know that several of the (synthetic rubber) companies have installed very expensive apparatus to pull off the fumes, but in many cases the systems either haven't been planned properly or haven't worked. That .... is the reason we are receiving complaints from workers that certain illnesses seem to follow working with these solvents .... we have to be very careful of our labor supply; and—even if from a purely selfish consideration of humanitarian demands —reduce to a minimum any of the ill effects of work in a particular job."

Those plants which have had a considerable turnover of labor in some departments and are puzzled as to the cause may find their answer in Mr. Sufrin's comments.

For lack of accepted terminology, "synthetic rubber" and "rubber substitute" will be used interchangeably in this discussion to indicate any of the synthetic materials which have rubber-like properties. The first part of the paper will consider the health hazards peculiar to the synthesis and handling of each of the more important substitutes, and the latter part will consider the hazards associated with a group of materials including accelerators, softeners, solvents, and other ingredients which are common to all of the synthetics.

Much valuable information is to be found in the two Industrial Safety Series pamphlets, numbers Ru-1 and Ru-3, published by the National Safety Council and based on the studies of Dr. L. J. D. Healy.[1, 2]

Based on a paper presented by the authors before the Rubber Section, 31st National Safety Congress.

The source material was assembled at a time when experience with the synthesis and fabrication of synthetic rubber in the United States was very limited. Furthermore, our being engaged in war and the close tie-up between synthetic rubber and military activities made it necessary to hold certain detailed information confidential. Rapid changes both in processes and in the materials being handled have modified and will continue to modify some of the specific data presented in this paper. However, the general principles of engineering control of potentially harmful gases, vapors and dusts, as outlined here, will apply to most operations connected with synthetic rubber. A section has been inserted just previous to the summary, listing some actual experiences by manufacturers and users of synthetic rubber in the health hazards and methods for their control. The bibliography has also been considerably augmented and brought up to date. MR. VAN ATTA'S present address is National Safety Council, Chicago.

These cover the potential harm of solvents, accelerators, pigments, etc. On May 29, 1942, the Division of Labor Standards of the U. S. Department of Labor called a conference in Akron on health hazards in the rubber industry. It was to be expected that the latest and most valuable information on health hazards peculiar to synthetic rubber would be found in the condensed proceedings.[3] Unfortunately, too much space was devoted to a "battle of experts" on the relative toxicities of two solvents; as a result, there is a minimum of information concerning other hazards, equally great, or greater. Whenever it comes to synthetic rubber, the transcript reads "off the record."

Neoprene

NEOPRENE [9, 10, 13] was chosen as the first substitute to be discussed in detail because it has been used longer and there has been more experience with it than with most of the other substitutes used in this country. The chief potentially hazardous materials in the synthesis are the starting material—acetylene, vinyl acetylene, hydrochloric acid, and chloroprene. The following equations indicate the course of the synthesis:

$$\underset{\text{Acetylene}}{2\ CH\equiv CH} \xrightarrow[NH_4Cl]{Cu_2Cl_2} \underset{\text{Vinyl acetylene}}{CH_2=CH-C\equiv CH} + HCl \longrightarrow$$

$$\underset{\text{Chloroprene}}{CH_2=CCl-CH=CH_2}$$

Acetylene may be classified with the asphyxiant gases. In fairly high concentrations it has a depressant effect on the circulation and respiration and is somewhat narcotic. The few recorded cases of industrial poisoning have raised some doubt whether the harm was done by the acetylene itself or by the hydrogen sulfide or phosphine which it may have contained as an impurity. Whatever the source of harm, it is apparent that workers must be protected from breathing this gas continuously even in moderate concentrations.

Vinyl acetylene has not been studied as an industrial poison. It is probably more toxic than acetylene but should still fall into the asphyxiant group of gases.

Like many of the other chlorinated compounds, *chloroprene*, a liquid boiling at 59°C (138°F), is considerably more toxic than its parent hydrocarbon. Inhalation of comparatively low concentrations of the vapor causes irritation of the respiratory tract. Continued exposure may produce a fall in blood pressure, reduction in the respiratory rate and cyanosis. The most severe effects are damage to the liver, kidneys and testicles, and internal hemorrhage due to the hemolytic action. Von Oettingen[5] suggests that concentrations of 0.3 milligrams per liter of air, corresponding to about 100 parts per million, may cause toxic effects after continued exposure. The maximum safe concentration will therefore be somewhere below this value. Not only is chloroprene a respiratory hazard, but it may be absorbed directly through the intact skin and produce essentially the same effects that it does by inhalation.

Hydrochloric acid is a powerful respiratory and skin irritant. The vapor concentration in the workroom air must be kept well below 10 parts per million.

The various steps in the synthesis of Neoprene are carried on in closed systems and the materials handled through pumps and piping. Dangerous concentrations of air contaminants may be produced wherever leaks may occur and acute exposures are presented in cleaning out tanks, reactors and piping. One of the larger rubber companies has adopted the following precautions in the synthesis of Buna S[31];

these would apply equally to all syntheses in which toxic and highly explosive liquids and gases are handled:

"Escaping vapors must be removed at their source by exhaust ventilation. At the same time general ventilation must be provided at the rate of 20 air changes per hour.

Exhaust ducts should be located at points where vapors are likely to be released, such as valves, gauge glasses and similar locations and also in pits and other dead air spaces where vapors may collect.

Skin contact with the liquid should be prevented by proper protective clothing.

Safety rules for cleaning out pressure vessels cannot be too strict; the following precautions must be taken:

1. All valves should be closed and sealed unless a safety man is stationed at such points to prevent their being opened.
2. Any agitators or other moving equipment must be locked out.
3. Before entering any such vessel it must be thoroughly purged. This can be done by a combination of several of the following: filling the vessel with water, steaming, applying vacuum, and exhausting. Before opening such a vessel evacuate to as much vacuum as possible, bring to zero (gauge) pressure with nitrogen, and repeat this process a second time.
4. Workmen entering vessel must be provided with suitable safety equipment such as goggles, rubber gloves, and forced air masks.
5. Any extension light used must be of approved vapor-proof type.
6. The workman must wear a manhole harness with a strong lanyard attached and another workman must remain on the outside and retain hold of the lanyard. In some cases where the manhole is near the bottom of the tank it may be practical to omit the manhole harness but there still must be another workman detailed to the specific duty of observing the workman who is inside.
7. The workman in the vessel must be instructed to come out at the first indication of dizziness or illness and must be removed to clean air.
8. It must be borne in mind that the vapors of butadiene and many of the other materials used in these processes when mixed with air are highly explosive and all receiving, storage, and processing must be handled accordingly."[25]

Intelligent application of the precautions outlined above will reduce to a minimum the health hazards to which workers are exposed in the manufacture of Neoprene or other synthetics.

One of the proposed methods for polymerization of chloroprene is carried out with a 25% solution of the monomer in benzol, toluol, or similar solvent, then adding phenyl beta naphthylamine as inhibitor. Here there is a potential exposure to a combination of hazards, the most serious being the aromatic solvents and chloroprene vapors. The inhibitor, phenyl beta naphthylamine, has been considered in the past to be relatively slightly toxic. We feel, however, that exposure to this substance should be avoided because of possible long-range effects. Beta naphthylamine has been known to cause bladder tumors in dye workers; the addition of the phenyl group would probably increase its carcinogenic activity. A more recent method for polymerization of chloroprene treats the monomer in aqueous dispersion with lead oleate, followed by the addition of the above inhibitor. Here the new hazard of lead is present and special precautions are necessary to prevent inhalation of the dust and skin contact with the lead soap.

Buna Rubbers

THESE are the polymers of butadiene and its copolymers with styrene (Buna S) and with acrylonitrile (Buna N, Perbunan, Hycar, Ameripol, Chemigum). None of the simple polymers has been proposed for commercial production in this country, and of the copolymers, the Buna S will be produced in largest quantity.[9, 10, 14, 26]

The synthesis of butadiene is a problem for the petroleum[15] and alcohol industries, rather than for the rubber industry itself, but the connection between these industries must be very close in the future, if it is not already so. Therefore, some discussion of the synthesis is pertinent to this article.

The German process of starting with acetylene, condensation to monovinyl acetylene, and hydrogenation to butadiene is not being given serious consideration in this country. Most of our butadiene will probably come from petroleum—vapor phase cracking of petroleum; dehydrogenation of butane; and chlorination of beta butylene followed by dehydrochlorination. Another major source of butadiene in this country (and the chief source in Russia) will be alcohol, both from fermentation and synthesis. A third type of synthesis is the fermentation of corn by aerobacter aerogenes to give 2, 3 butylene glycol, esterification to the diacetate, then pyrolysis to yield pure butadiene:

$$\text{Corn} \xrightarrow[\text{aerogenes}]{\text{aerobacter}} \underset{\text{2, 3 butylene glycol}}{CH_3-CHOH-CHOH-CH_3} \xrightarrow{HAc} \underset{\text{diacetate}}{CH_3-CHOOAc-CHOOAc-CH_3} \xrightarrow{500^\circ C} \underset{\text{butadiene}}{CH_2=CH-CH=CH_2}$$

Styrene is ordinarily prepared from benzol and ethylene, with aluminum chloride as the catalyst, and dehydrogenation of the resulting ethyl benzene. Coal tar may also be used as the starting material.

$$\underset{\text{Benzene}}{C_6H_6} + \underset{\text{Ethylene}}{CH_2=CH_2} \xrightarrow{AlCl_3} \underset{\text{Ethylbenzene}}{C_6H_5-CH_2-CH_3} \xrightarrow{800\text{-}950^\circ C} \underset{\text{Styrene}}{C_6H_5-CH=CH_2} + H_2$$

Acrylonitrile may be prepared by any of the three processes shown in the following formulas. The method of choice in the future will probably be the third one, involving ethylene oxide and hydrogen cyanide, since it does not involve any chlorine.

$$CH_2OH-CH_2Cl + NaCN \rightarrow CH_2OH-CH_2CN \xrightarrow{KHSO_4} \underset{\text{Acrylonitrile}}{CH_2=CH-CN}$$

$$CH_3COO-CH_2-CH_2-CN \xrightarrow{\text{heat}} CH_2=CH-CN + CH_3COOH$$

$$CH_2\overset{O}{\diagdown\!\diagup}CH_2 + HCN \rightarrow CH_2=CH-CN + H_2O$$

Most of the raw materials and intermediates in these syntheses are highly toxic by inhalation and a number of them by skin contact also. The same precautions will be required generally as those recommended for the synthesis of Neoprene, in order to prevent illness and accidents among the workers.

What directly concerns the manufacturer of rubber substitutes is the materials he receives for polymerization.

Butadiene will be the most important from the standpoint of amounts handled in the industry. It is received as a liquid boiling at -3°C (26.6°F). One concern reports the following effects from exposure to the vapors:

"Irritation of the eyes, nose and throat, but apparently no cumulative effects. Below the lower explosive limit (2%) it is mildly narcotic, but in higher concentrations it is acutely dangerous."

There is very little information in the literature about the physiological effects of butadiene. The recorded observations,[6] which are mainly concerned with the effects of repeated heavy exposures, may

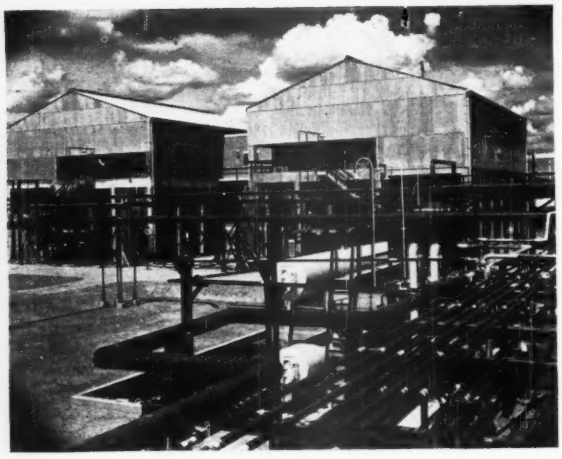

Fig. 1.
Reactor Area of Synthetic Rubber Plant
(Courtesy, Dayton Rubber Company)

have to be modified when there has been a more complete study of the effects of continued exposure to low concentrations. The low boiling point of the liquid should serve as a warning to avoid skin contact.

Styrene is a liquid boiling at 145°C (293°F). Its obnoxious odor would prevent a worker from voluntarily entering or remaining in a room where the vapor concentration is high. However, this cannot be relied on as a control measure because the sense of smell becomes dulled after prolonged exposure to even the strongly odorous vapors and gases. Exposure to styrene vapors may cause irritation of the skin and especially of the mucous membranes of the eye.[24, 31] The vapor is also narcotic in comparatively low concentrations. Irritation of the lungs, and liver and kidney damage will follow heavy exposures. Concentrations of 200 parts per million have been suggested tentatively as a safe maximum.

The role of personal cleanliness in prevention of skin irritation by contact with styrene is shown by the experience of one large rubber company that there were more cases of dermatitis among janitors than among operators in a Buna-S plant. The exposure of the operators was probably heavier than was that of the janitors, but much less difficulty was experienced in convincing the operators of the necessity for cleaning up immediately after any contact with the liquid.

Acrylonitrile is a liquid boiling at 78°C (172°F). The toxic effects of this compound are apparently due to the formation of hydrogen cyanide in the body after the material has been absorbed. Neal [21, 22] has found a typical cyanide reaction following absorption. Therefore, he has suggested a tentative safe limit of 20 parts per million. Acrylonitrile is by far the most dangerous material so far discussed and must be handled with extreme care. Since acute effects may follow even moderate exposures, anyone who shows the slightest symptoms should receive immediate medical attention. It is well known that cyanides are easily absorbed through the skin. For this reason skin contact with acrylonitrile must be avoided and accidental spillage on the skin must be immediately washed off with alcohol or large quantities of water.

Polymerization is usually carried out in a water emulsion, with the addition of soaps as emulsifying agents, catalysts (such as peroxides, persulfates or peracids), and modifying agents which may be halogenated hydrocarbons, nitriles or sulfur compounds. Some of the suggested modifying agents are trichlorpropionitrile, carbon tetrachloride, sodium cyanide, mercaptans. They are mostly substances of known high toxicity and must be handled with great care, that is, inhalation of vapors and skin contact with these materials must be prevented. The point of greatest danger is the removal of the modifying agents from the latex which they have helped to polymerize.

Constructions such as are shown in Fig. 1 will minimize the probability of the accumulation of dangerous amounts of vapor. Fig. 2, taken in the same area of the same plant, shows that even with construction specially designed to minimize vapor concentration there is still a necessity for ventilation. An area of this sort cannot be considered safe without special ventilation to remove the vapor which may escape from meters or fittings. The multiplicity of possibilities for the escape of vapor here will also emphasize the desirability of a regular program of air sampling even when it is thought that the ventilation is ample to remove any probable leakage.

Isobutylene Polymers

THE member of this group which will be commercially important is the copolymer of isobutylene with a diolefine such as isoprene or butadiene. This introduces the new hazard of butenes which are considered by some experimenters to be of about the same toxicity as butadiene. The butenes are colorless gases with boiling points between -6° and 2°C (21° and 36°F). We have no reason to believe that the control measures should be other than those recommended for butadiene. In polymerizing butene with diolefines to form Butyl rubber two highly volatile, flammable gases are being handled at the same time, which would make the fire and explosion hazard greater than with other copolymers thus far discussed. When isobutylene itself is polymerized the product formed cannot be vulcanized by present methods and therefore finds limited commercial application. Trade names for the isobutylene polymer are Vistanex and Oppanol.

Thiokols

THESE are made by condensing sodium polysulfide with chlorinated hydrocarbons.[19] Depending upon

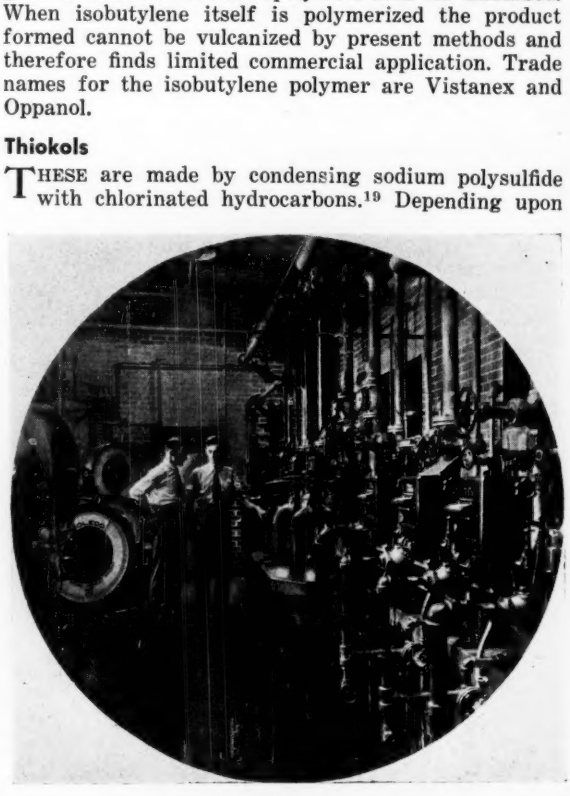

Fig. 2.
Metering Area of Synthetic Rubber Plant
(Courtesy, Dayton Rubber Company)

which chlorinated derivative is chosen, a variety of rubbery materials can be obtained. The two chlorinated derivatives most frequently used are ethylene dichloride and dichlorethyl ether, both highly toxic.

$$\underset{\text{Ethylene dichloride}}{CH_2Cl-CH_2Cl} + Na_2S_4 \rightarrow \underset{\text{Thiokol A}}{-CH_2-CH_2-S-S-} + 2NaCl$$

$$\underset{\text{Dichlorethyl ether}}{ClCH_2CH_2OCH_2CH_2Cl} + Na_2S_4 \rightarrow$$

$$\underset{\text{Thiokol B}}{-CH_2-CH_2-O-CH_2-CH_2-S-S-} + 2NaCl$$

Ethylene dichloride (dichloroethane) is a liquid boiling at 84°C (183°F), and is considered of the same order of toxicity as carbon tetrachloride. The suggested maximum permissible concentration for the vapors is 50 p.p.m.[29] Irritation of the throat, coughing and vomiting have been reported as initial symptoms in man. The possibility of liver damage and other effects of prolonged exposure to moderate concentration indicates the need for keeping the vapors out of the breathing zone of workers.

Dichlorethyl ether is a liquid boiling at 178°C (352°F). Its close relation to the war gas, dichlormethyl ether, suggests that it too may cause irritation of the eyes and lungs. One state has set a maximum permissible concentration for the vapors at 15 p.p.m. A concentration of 35 p.p.m. is said to produce a perceptible odor without producing irritation.[32]

Because the reaction takes place in aqueous medium and the product is coagulated with acid, the hazard of *hydrogen sulfide* must be considered in both parts of the process. Past experience has shown that hydrogen sulfide may cause irritation of the eyes, nausea, and headache, as well as loss of appetite and loss of weight when workers are exposed even to moderate amounts day after day. Therefore, hydrogen sulfide should be removed at the source of generation so that the concentration in the workroom air does not exceed 20 p.p.m. At least one article[18] has appeared in which the source of thiokol odors has been discussed. It is believed that *ethylene mercaptan* and other sulfur-containing compounds are formed. These may be highly toxic as well as disagreeable. If the hydrogen sulfide is removed at the source, mercaptans and the other toxic gases will be controlled at the same time.

Vinyl Polymers

Two of the most important members of this group[17] are polyvinyl butyral (Saflex) and polyvinylidene chloride (Saran). Common to all of these compounds is the hazard of acetylene, the basis for synthesis of the monomers. The monomer for polyvinylidene chloride is made by treating ethylene dichloride with alkali, by addition of hydrogen chloride to acetylene, or by substitution of chlorine in ethylene.

$$ClCH_2CH_2Cl + NaOH \rightarrow HOCH_2-CH_2Cl + NaCl$$

$$HOCH_2-CH_2Cl \rightarrow \underset{\text{Vinyl chloride}}{CH_2=CHCl} + H_2O$$

$$\underset{\text{(Acetylene)}}{HC\equiv CH} + HCl \rightarrow \underset{\text{Vinyl chloride}}{CH_2=CHCl}$$

$$\underset{\text{Ethylene}}{H_2C=CH_2} + Cl_2 \rightarrow \underset{\text{Vinyl chloride}}{CH_2=CHCl} + HCl$$

Vinyl chloride is a gas at ordinary temperatures, with boiling point of -12°C (10°F). Fairly low concentrations may cause dizziness and confusion without previous warning.

Harmful materials involved in making other monomers and in effecting polymerization may include: hydrogen chloride, butyraldehyde, and several catalysts —mercuric sulfate, benzoyl chloride and uranyl acetate in methanol. The various processes are carried on in a closed system. Therefore, use of the precautions given previously for such handling—proper ventilation and avoidance of skin contact—should control the hazards.

Compounding and Vulcanization

The synthetic rubbers which will be most important commercially will be compounded and handled in much the same manner as natural rubber. This is more than a coincidence, for otherwise the available equipment of the rubber industry in this country would be useless. Likewise, the compounding ingredients are generally similar to those used with natural rubber. In the following sections these ingredients will be considered in groups.

Organic Accelerators and Antioxidants

Shortly after the development of accelerators and antioxidants and their use in the rubber industry many workers began to suffer ill effects from exposure to these complex chemicals. Among the early offenders, aniline and some of its derivatives; "hexa" (hexamethylene tetramine); the toluidines; and paraphenylenediamine caused so many cases of poisoning and dermatitis that there was a rush to develop harmless or less harmful substitutes. Some of these substitutes have been used with no reports of harmful effects, but most of the available information has come from direct questioning of rubber fabricators, not from toxicological experiments. Almost without exception this group of materials is identified by chemical names which are extremely unwieldy and the tendency in this industry is to use trade names "D.P.G.," "Tuads," etc. This makes it all the more important that Dr. Healy's work in classifying these materials according to potential harm,[1, 2] be continued and brought up to date. Also an organized start should be made in studying the effects of these compounds in controlled experiments and within the industries themselves.

The compounds most frequently mentioned in working formulas for synthetic rubber are:

Diphenylguanidine (D.P.G.)	
Benzothiazyl Disulfide (Altax)	
Mercaptobenzothiazole (Captax)	
Tetramethylthiuram Disulfide (Tuads)	
Hexamethyleneammonium Dithiocarbamate (Latac)	
Dinitrophenyl Dimethyldithiocarbamate (Safex)	
Dihydroquinoline derivatives (Flectols, Agerite Syrup)	
Phenyl α-Naphthylamine, Phenyl β-Naphthylamine, and mixtures with m-toluenediamine	(Neozone, Neozone A, Neozone B, Neozone C, Neozone D)

Because of toxic and irritating effects some of these accelerators have been prohibited on government contracts by the Chemical Warfare Service. Impurities account for the danger in using some of the complex compounds; for example, aniline has been found as an impurity in several of the Neozones. Safe practice would dictate avoidance of exposure either by inhalation or skin contact, not only because of immediate effects but because prolonged exposure may result in serious injury. Absorption through the skin may be minimized by the use of protective creams—the so-called "Chemical Gloves"—and by frequent and thorough cleansing of the exposed parts of the body.

Inorganic Accelerators

Although no dust should be promiscuously disseminated into the atmosphere, the toxic dusts are the ones to be especially avoided. The inorganic accelerators most frequently recommended are the oxides of zinc and magnesium; these may create a nuisance

but have not been shown to have any definite harmful effect. However, lead oxide, mercuric oxide, and selenium compounds have been recommended and used for special properties, and the dusts of these compounds must be removed by local exhaust ventilation both in weighing out batches and in incorporating them on the mill. Lead has also found use, both as the oxide and in the form of a soap during polymerization by emulsification. Of course, both uses call for extreme caution in handling. The history of poisoning by both lead and mercury is so well known that there is no excuse for careless use of their compounds in modern industry.

Plasticizers

THE working formulas for compounding of most synthetic rubbers call for relatively high proportions of plasticizers. With some of the plasticizers there is little danger during incorporation into the mix, but a real hazard is presented when they are volatilized during vulcanization. Dibenzyl ether, dibutyl phthalate and tributyl phosphate have been reported to cause irritation of the upper respiratory passages and nose-bleeds.

Chlorinated naphthalenes have been recommended as plasticizers in special applications. The long history of severe dermatitis, poisoning, and death from the use of these compounds in industry should impress upon those planning to use them the necessity for removal of the vapor at the source by local exhaust ventilation and skin protection plus supervised washing to eliminate the skin hazard. Washable uniforms should be provided and laundered frequently. Separate lockers for work clothes and street clothes of all workers handling the chlorinated waxes are necessary.

Solvents

THESE represent one of the greatest hazards in the use of synthetic rubber. Solvents are used in great quantities and they generally are of the most toxic varieties. The operations in which the hazard is greatest are preparation and use of cements, preparation and use of extrusion mixtures, preparation and application of fabric coating mixtures and subsequent drying of the fabrics by heat.[23] Some of the specific applications in which these harmful exposures are most common are: manufacture of raincoats and similar impervious clothing, manufacture of airplane fuel tanks and balloons,[23] manufacture of gaskets and packings.

The resistance of these rubber substitutes to ordinary solvents has required the use of such highly toxic materials as the aromatic hydrocarbons—benzene, toluene and higher homologues; the chlorinated hydrocarbons—carbon tetrachloride, ethylene dichloride, monochlorbenzene, etc.; methyl ethyl ketone, butyl alcohol.

Benzene has been responsible for so many poisonings in industry that it has elicited such extreme opinions as: "The safe concentration of benzol in the workroom air is zero." Several years ago a safe level of 75 parts per million was proposed. Why the American Standards Association upped this to 100 parts per million a few years later we cannot understand. We believe that a solvent which is so dangerous to the blood should, in fact, be controlled by the best engineering methods to approach as closely as possible the ideal concentration of zero in the workroom air. Closely related to benzene and proposed by some as a safe substitute is toluene. The suggested safe limit varies from 100 to 200 parts per million. Recent work has shown that an eight hour exposure to 200 parts per million dulls the senses to the extent that the worker becomes more accident prone.[27] The severe poisonings and deaths which have resulted from the use of toluene as a substitute for benzene, with no control of the vapors, illustrates the fallacy of not instituting control measures until specific physical harm has been suffered by the workers exposed. In searching for a safer substitute it should be borne in mind that physical properties, such as boiling point, do not necessarily give a true measure of the vapor concentrations. The temperature at which the solvent is used must always be considered. Toluene is now allocated to special war purposes and benzene is once more in common use in the rubber industry. We trust that adequate precautions will be taken and that the vigilance will not be relaxed when toluene again returns to this industry.

The chlorinated solvents have a long history as industrial poisons. Studies in recent years[30] have indicated the safe limit for carbon tetrachloride vapors should be reduced from the value of 100 parts per million probably to the range of 25 to 50 parts per million. The suggested safe limit for monochlorbenzene is 75 parts per million.

For butanol and methyl ethyl ketone, which are used primarily with the vinyl polymers, the suggested safe level is 100 parts per million.

Bunas and the butyl rubbers are the only common synthetic rubbers which are appreciably soluble in aliphatic hydrocarbons. If the petroleum derivatives used for dissolving these rubbers contain aromatics, as many have been found to do, the suggested safe limit of 1,000 parts per million (for gasoline) must be scaled downward. Before using solvents, or for that matter accelerators, antioxidants, etc., which are identified only by trade names, the rubber manufacturer will be using proper caution only if he learns what they really contain. If he has the facilities, he can have them analyzed in his own laboratories. Often it is simpler to communicate with the manufacturer of the solvent or other material. Or, governmental agencies may assist the user in appraising the danger from some of the trade-named materials.

Because so many instances have been observed of a window exhaust fan or wall fan being used to remove solvent vapors, and even dusts, we want to emphasize here that as a rule such installations are not only ineffective but may actually increase the hazard by moving the contaminant towards the worker. Most important in the control of solvent vapors is removal of the vapors as close to the point of generation as possible, and in such a way as to carry the exhausted air away from the worker. Nor is the current rage for down-draft exhaust entirely justified. Although the concentrated vapors of most solvents are heavier than air and would flow downward in a draft-free area, it is obvious that a down-draft exhaust beneath the table cannot possibly remove solvent vapors from the top of a broad table without first carrying them into the breathing zone of the workers along the edge of the table. Lateral exhaust is effective at many spreading and cementing operations. Ventilation near the floor may be used to reduce the fire hazard but it is not necessarily effective in protecting the workers from inhalation of the vapors. This should be immediately obvious from the fact that toxic concentrations are measured in parts per million while explosive concentrations are measured in percentages. The numerous cases of illness and death reported among workers at spreading tables indicates that more attention will have to be paid to the design of effective exhaust systems at these operations. Finally, it must be remembered that whenever it is impossible or impracticable to protect the worker from harmful concentrations of solvent vapor by local exhaust ventila-

tion, the reliable alternative is a supplied-air respirator properly used.

Vulcanization

THIS admittedly complex process can give rise to a number of toxic gases, such as hydrogen sulfide, carbon disulfide, mercaptans, etc. When Neoprene was introduced as a rubber substitute, there were frequent complaints of a "tear gas" generated during vulcanization. Most processors state that the newer types do not give off obnoxious gases. The Thiokols, however, still retain the reputation of being the smelliest members. These possibilities of poisonous and irritating gases during vulcanization[18] show the need for adequate control by exhaust ventilation.

Dusting

FOR a long time it was thought that free silica and asbestos are the only hazardous dusts from the standpoint of pneumoconiosis. In recent years it has been shown[28] that silicates such as talc and mica may cause a lung disease called "silicatosis." For this reason, and the fact that it makes a great difference in plant housekeeping, dusting should be done on tables provided with enclosures and exhaust ventilation. Our own observations have shown that uncontrolled dusting operations usually produce air concentrations far in excess of the proposed maximum limit of 15·000,000 particles per cubic foot of air.

Actual Experiences

THE following are direct quotations from letters answering our requests to those industries having experience in making and using synthetic rubber for their opinions of the hazards [31]:

(1) ". . . . due to the narcotic properties, exposure to butadiene vapor is likely to be a contributing factor in other accidents since the workman may experience a heavy feeling and a dulling of his senses.

". . . . that butadiene be handled in closed systems with immediate elimination of any leaks . . . . vapors must be removed at source.

"The obnoxious odor of styrene is likely to make dangerours concentrations intolerable to workmen."

(The same plant providing the above information makes the following statement.)

". . . . we have not suffered any lost time accidents . . . . workmen have shown no ill effects after five months of operation. We have had practically no trouble with dermatitis . . . . we provide work clothing, free laundry service, free soap, and encourage our workmen to bathe thoroughly at the conclusion of their work day.

". . . . the manufacture of synthetic rubber is hazardous but many of the hazards can be eliminated or modified by a good safety program . . . ."

(2) "Plasticizers for butadiene of low boiling points . . . . should be avoided. Many esters and ethers which fall in this group have given us trouble . . . . dibutyl ether resulted in marked irritation . . . . of nasal passages with frequent nose bleeding. Tributyl phosphate was very bad. During hot weather, workers handling Hycar which contains phenyl beta naphthylamine . . . . suffer from dermatoses of exposed parts of the body. Rashes below the elbow were frequent. Part of this may have been caused by dibutyl phthlate."

(3) ". . . . in Neoprene and Butyl rubber lead compounds are frequently used."

(4) "The accelerators, curatives, and compounding ingredients used in rubber are also commonly used in most of these synthetics . . . . use the same precautions that have always been considered advisable in handling those materials which may present a hazard . . . . tetramethylthiuram-disulfide (Tuads) may cause dermatitis . . . . solvents used in washing uncured sheets of compounded synthetic rubber are usually toxic . . . . coal tar derivatives are the worst offenders (benzol, toluol) . . . . chlorinated solvents are also toxic . . . . Proper ventilation seems to remove all health hazards connected with solvents."

Summary

THE data presented in this paper can best be summarized by a review of the most hazardous operations and the proper means for their control.

Synthesis and Polymerization—Highly volatile liquids and gases, most of them quite toxic and highly flammable, are pumped from reservoirs into reaction vessels. Control measures include ventilation wherever gases or vapors may escape, prevention of skin contact, and a strict set of safety regulations, as outlined above, for all operations requiring a worker to enter tanks or reaction vessels.

Fabrication—Avoid use of the known bad actors among accelerators, antioxidants, etc., if possible. In any case, wherever potentially toxic materials are handled, the resulting air-borne dusts and vapors should be removed at the source by exhaust ventilation. The processes which may be the source of these contaminants are: weighing, mixing on mill or Banbury, extrusion, vulcanization, dusting, spreading, and cementing.

The greatest enemy of industrial health, as well as industrial safety, is ignorance. If we acquaint ourselves with the actual and potential hazards in our plants, install the proper control measures, and educate our workers to the potential harm in the materials to be handled and how to use the protective devices provided, we will get better production and less labor turnover.

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Comments on "Radium Painting" by Morse and Kronenberg

—in Industrial Medicine, December, 1943—

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THE excellent paper on "Radium Painting—Hazards and Precautions" by MORSE and KRONENBERG in INDUSTRIAL MEDICINE, December, 1943, provides an interesting picture of the present status of the hazard in the painting of luminous dials, and an admirable supplement to the one by EVANS (*J. Indust. Hyg. & Tox.*, September, 1943, p. 253).

A rather important question arises on consideration of the results of breath radon tests which reflect the amounts of radium that are contained in the bodies of many dial painters. The question is, how do these workers receive radium in their bodies? The answer to the question is important because it will indicate which are the important preventive measures. As anyone will realize who has had occasion to study operations in dial painting establishments, the answer is not at all obvious, for as EVANS has indicated, excessive radium intake is found among workers in shops where the highest standards of housekeeping and cleanlinesss are adhered to.

MORSE and KRONENBERG emphasize the importance of personal cleanliness, especially of the hands, to avoid ingestion of radium-containing paint with the food or otherwise. This is the view generally taken by all concerned with this problem (see also papers by FLINN (INDUSTRIAL MEDICINE, October, 1941, p. 57) and MORRIS *et al.* (*J. Indust. Hyg. & Tox.*, September, 1943, p. 270). We certainly do not claim that cleanliness is not of importance, but we do believe that reason indicates that inhalation of dust is far and away the most important avenue of entry to the body.

It has been generally recognized for decades, in considering such hazards as lead dust, that inhalation of toxic dusts is responsible for occupational poisoning to an overwhelming degree as contrasted to poisoning from ingestion of dust. It is pertinent to recall once again that a worker inhales 25-30 pounds of air during a working day, compared to a food and liquid intake of 3-4 pounds in the same period.

Just as it was common years ago to lay almost all emphasis on those practices that would minimize the ingestion of lead dust by the alimentary tract, so today we are emphasizing the same aspect in the dial painting occupation. We suggest that this obscures the inhalation hazard which we believe of much greater importance.

Consider the fact that an intake (and retention) of 2 milligrams of radium paint represents the maximum safe body content, not daily, but for all time.

Two milligrams of radium paint powder would occupy a volume roughly the size of a common pin head. If dispersed in air in such concentrations that it would all be inhaled over a period of a few days, it would obviously be considered an extremely small amount, and anyone familiar with small concentrations of lead dust and the nature of industrial operations that can cause them will have little difficulty in conceiving of an occasional, localized atmospheric dust hazard even in a high grade dial painting shop.

On the other hand it is difficult to conceive of a pin head volume of dust being ingested with food, *after* washing the hands with soap and water, by a substantial number of workers, even though, as MORSE and KRONENBERG report, "the best previously practiced personal hygiene will not remove this paint." Our view is that, if thorough ordinary washing does not remove such paint from the skin, it seems unlikely that it could be ingested by transferral to food in significant amounts.

Furthermore we consider the authors' observation that relatively large amounts of paint dust were found in ventilating ducts and fans tends further to support the view that atmospheric dust in significant amounts occurs frequently in this work and is, therefore, the most important hazard.

This observation, incidentally, provides the most important answer to the question raised by the authors as to whether or not we "have accepted too readily the glass top booth." The more important function of local exhaust is in *dust* control rather than radon control (see paper by HEMEON and EVANS, *J. Indust. Hyg. & Tox.*, May, 1942), and the observation as to accumulation of dust in exhaust ducts is, to our mind, the most convincing evidence of the desirability of local exhaust. As for the particular form of local exhaust, there is no good reason why the slot exhaust at the rear of the work bench described by the authors would not serve as well as a glass top booth. However, as it requires exhausting a greater air volume than the booth, there are some circumstances where it would not be indicated.

On another point we differ with the authors, namely, the importance of the tolerance value for radon, 10^{-11} versus 10^{-10} curies per liter of air. It is stated that "controversial opinions . . . . in the order of 10 to 1 mean considerable regarding the physical requirements for control measures," and that there is justification for re-examination of these values. It is, of course, understood that we are writing from the engineering viewpoint, and from that angle we point out the following: The highest values that have been published showing the concentrations of radon in workrooms are of such magnitude that (1) they never approach the higher safe limit that has been proposed, i.e., 10^{-10} curies/liter; and so, according to this standard, there is never any hazard from radon; and (2) the highest values reported are only twice the lower proposed safe limit—i.e., even using the more conservative limit of 10^{-11}, the radon hazard is mild even under conditions of poor ventilation, and an exhaust system for minimizing the dust hazard would bring

the values down to a fraction of the conservative limit. In other words, it is easy to be safe and it does not penalize the industry. Therefore we suggest that the re-examination proposed would be of only academic concern—certainly not of engineering interest.

Arsine, Stibine, and Hydrogen Sulfide

—Accidental Generation in a Metal Refinery—

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ARSINE (hydrogen arsenide) is a colorless, inflammable, non-irritating gas with a specific gravity of about two and one half times atmospheric air and a very faint garlic-like odor. It is formed whenever nascent hydrogen is produced in the presence of a soluble compound of arsenic. Such formation is not uncommon when an acid reacts with a metal either or both of which contain traces of arsenic. Poisoning has occurred in a number of industries in which hydrogen is produced and/or used, unless the hydrogen is produced electrically (arsenic free).[1] Examples of such industries are:

1. Filling of small or large balloons.
2. Welding and cutting with blow torches.
3. Metallurgy.
4. Soldering.
5. Etching with zinc, and
6. In chemical laboratories.

It is also liberated from metallic arsenides, such as calcium arsenide, by the action of water.

Stibine (antimony hydride) is an odorless gas about four and one half times as heavy as air[2] formed by reactions identical to those for the formation of arsine. It has been found to be generated by storage batteries on overcharge,[2] and will be formed whenever nascent hydrogen comes in contact with metallic antimony or with a soluble antimony compound.

The toxicity of arsine has been recognized for many years. Henderson and Haggard,[3] in "Noxious Gases," discuss the physiological effects in considerable detail. They summarize the response as follows[2]:

	Arsine P.P.M.
Slight symptoms after several hours exposure	30
Dangerous for exposure of one hour	50
Fatal to man in exposure of 30 minutes	250

The literature, however, gives us little information about the effects of stibine on man. Stock and Guttman[2,4] concluded that the toxicity of stibine is similar to that of arsine. This has been confirmed by Haring and Compton.[2]

Hydrogen sulfide is also a colorless gas, heavier than air, with a very objectionable odor and an irritating effect on the mucous membrane of the eyes, nose and throat, the respiratory tract in general and also on the cornea of the eye. It is met frequently in the petroleum industry, in mines, in the coal and gas industry, and in the handling of slags. It may be formed in a manner identical to that of the formation of arsine and stibine, namely, the action of nascent hydrogen on metallic sulfur.

Generally speaking, the toxic effects of hydrogen sulfide are well known and, since the presence of the gas is easily and quickly detected by its odor, preventive and control measures are usually provided.

Arsine and stibine, however, being essentially odorless and rarely encountered, and occurring in operations where they are often not expected, may accidentally lead to poisoning. Such a condition arose recently in a metal refinery as a result of a change in a process of purification and an unauthorized activity—resulting in the poisoning of three employees by arsine, stibine and hydrogen sulfide. The exposure was of a relatively short duration, and each of the three men recovered.

As a result of the war it has been necessary for this refinery to accept ores from various sources and with varying compositions. Recently the ore has contained relatively high percentages of impurities of arsenic, antimony, copper, etc. To reduce these objectionable impurities to permissible limits a process was developed using metallic aluminum. This metal is added as sticks or sheets to the molten metal (1200° F) in excess while the mass is being stirred in a rotary manner; and is dropped in the center of the vortex. It is thought that the aluminum combines with the arsenic, antimony, copper and excess sulfur added in the course of refining, etc., and that these combinations appear in the dross which is brought to the surface most effectively by bubbling air through the molten mass. Such procedure naturally leads to the formation of a relatively large quantity of oxide of the metal desired to be purified. This oxide also constitutes a major portion of the dross. After the dross has been brought to the surface it is skimmed off while still hot, by means of a large metal skimmer operated by overhead crane. It is dumped into a large metal bucket in which it was intended to be cooled through natural processes. Several employees, however, conceived the idea of adding water to cool the dross more rapidly and also to settle the oxide dust. They provided themselves with a garden hose attached to an ordinary faucet and as soon as the bucket containing the hot dross was delivered to them they "poured on the water."

This addition of water to the hot dross was begun at 8:00 A.M. By 9:00 A.M. of the same day a white man, working on the platform adjacent to the operation of adding the water, became ill complaining of weakness, headache, and abdominal and lumbar pain. He left the job at 9:00 A.M.

The colored boys who added the water state that as the water hit the hot dross a yellow and often blue flame "leaped up" and that there was a tremendous evolution of gas with a musty odor and irritating effect on eyes, nose and throat. One of these colored boys noticed his urine to be "bloody" at noon of the same day; and by 3:00 P.M. he felt so weak and nauseated and had such severe abdominal and back pains, as well as headache, that he "checked out." The other boy also felt sick with identical symptoms, but he stayed on the job until 5:00 P.M. The next morning they both reported to first aid and were sent to the plant physician.

All of the operations described are carried out in a very large building with exceedingly high ceilings. Natural ventilation alone is available.

Laboratory Studies

SAMPLES of the dross were obtained; 300 grams is put into a round-bottom flask provided with a dropping funnel and a thermometer and connected to three fritted glass bubblers each containing 200 cc. of 10% lead acetate and finally to two bubblers each containing 100 cc. of 5% silver nitrate solution. The dross is heated to 95°C and a few cc. of water are dropped into the mass. The entire system is connected to a suction pump and air is drawn through the system at a uniform rate. Within a few seconds after the addition of the water, the silver nitrate becomes almost black while the lead acetate solution changes only slightly in color. The temperature is raised to 110°C, and another 10 cc. of water is added. At this point the lead acetate solution

rapidly becomes black and the silver nitrate solution color changes become more marked.

The black precipitate ($SbAg_3$) is filtered off. Dilute HCl is added to the precipitate and the mixture filtered. Water is added to the filtrate and a small quantity of AgCl is filtered off. The addition of H_2S to the filtrate causes the formation of the orange-red Sb_2S_3. The precipitate insoluble in dilute HCl is dissolved in aqua regia and found to be reduced silver. The solution of silver nitrate from which the $SbAg_3$ has been removed (arsenous acid) is treated with a solution of NaCl, the AgCl filtered off and the filtrate treated with H_2S. The canary-yellow As_2S_3 is formed.

Conclusions

THE addition of water to the hot dross containing metallic aluminum causes the formation of nascent hydrogen which reacts with the arsenic, antimony and sulfur to form SbH_3, AsH_3, H_2S.

2. These gases are produced in sufficient quantity to be observed to be toxic to three employees exposed in the building.

3. The reaction requires an elevated temperature for the production of amounts of these gases adequate to be detected by the use of lead acetate and silver nitrate solutions.

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Long Island College of Medicine, November 1-12, 1943.

American Industrial Hygiene Association
News of Local Sections

Chicago Section

EFFECTS of dust on health and a specific control measure were the subjects of the January 27, 1944, meeting of the Chicago Section. DR. L. E. HAMLIN, Medical Director, American Brake Shoe Company, Chicago gave a comprehensive review of "Silicosis for the Industrial Hygienist." His discussion included the fundamentals of the condition, and was of interest not only to those who were not too completely familiar with the subject but also to those of the group who had long been familiar with silicosis, in view of the clarity of detail which DR. HAMLIN included. Of especial interest were the slides showing a photograph of a worker exposed to dust and then the appearance of his chest x-ray. These illustrated the essentialness of x-rays in any medical control program where there is exposure to silica dust.

MR. C. A. SNYDER, Supervising Engineer, American Foundry Equipment Company, Mishawaka, Indiana, gave the engineering details of "Exhaust booths for dust control in grinding operations." Slides showing actual installations were used to illustrate MR. SNYDER'S talk. Members of the Chicago Section were interested to learn that successful results have been obtained from this method.

The February 24, 1944, meeting was presented by the Industrial Hygiene Division of the Illinois State Department of Labor, under the direction of JAMES E. CROSSER, JR. An extensive investigation of health hazards in soldering operations occurring in a large number of plants has been in progress by the Division. Much material was presented concerning the extent of exposures to lead which were found to be excessive in operations where poor housekeeping was observed, and especially where there was poor housekeeping with no exhaust ventilation. Operations provided with proper exhaust ventilation together with good housekeeping were found to present no excessive lead hazard. Some results of this investigation have been published by the Illinois State Department of Labor, and reprints of these may be obtained on addressing MR. JAMES E. CROSSER, JR., Chief Chemist.

"Recent Exposures and Special Problems in Occupational Disease" was the subject presented by MR. A. M. NOYES, Industrial Hygiene Engineer. A number of such examples were indicative of the type of exposure that should be looked for.

Metropolitan New York Section

DR. A. G. CRANCH, Industrial Toxicology Department, Union Carbon & Carbide Corporation, discussed the subject "Hand Cleaners" at the December 16, 1942, meeting. His talk included consideration of choice of hand cleaner depending upon the material with which the hands are in contact, desirable and undesirable types of cleaners, and the relation between hand cleaners and dermatitis. The following officers were elected, DR. A. G. CRANCH, Chairman; W. R. BRADLEY, Vice-Chairman; M. B. JACOBS, Secretary-Treasurer; and LT. J. SIEGEL, USNR, Councilor.

"Recent Developments Concerning Hazards of Magnesium" were discussed by MR. C. B. FORD, Division of Industrial Hygiene, New York State Department of Labor, at the January 14, 1944, meeting. MR. FORD cautioned that the conventional, dry-type of dust collector must never be used for the collection of this inflammable dust, as such systems have accident records which prove them to be extremely hazardous. Grinding wheel sparks fanned into flame inside the collector pipes are probably the cause of ignition. Two instances were described where explosions occurred in these systems, which caused the death of a number of workmen. The only systems considered safe for the exhaust and collection of Mg. dust are those employing the wet-quenching principle in which the dust is precipitated by either a heavy spray of water or mineral oil. Other safe practices discussed concerned adequate protective clothing for workmen who come in contact with magnesium dust, disposition of waste dusts and sludges and the approved methods of extinguishing magnesium fires. A Factory Insurance Association dust explosion chamber which is used for determining the explosibility of a dust was displayed.

The following committees were appointed: Membership, MR. BRADLEY, MR. PATTY; Public Relations, MR. PATTY, MR. SIEGEL and MR. SEAGRAVE; Program, MR. BRADLEY, MR. BONSIB, MR. GUMAER and MR. JACOBS.

"Protection of Workers against Industrial X-Ray Exposure" was discussed by MR. S. A. BARNETT, Ray Proof Corporation, New York at the February 17, 1944, meeting.

Michigan Section

THE Michigan Industrial Hygiene Society has been holding a number of meetings in cities throughout the state. A meeting held in Kalamazoo on January 19, 1944, was addressed by MR. WARREN A. COOK, Director, Division of Industrial Hygiene and Engineering Research, Zurich General Accident & Liability Insurance Company, Chicago, on the subject "Evaluation and control of industrial health hazards." MR. COOK emphasized the desirability of proper evaluation of health hazards as an effective approach to their proper control.

On February 9, 1944, MAJOR ALLEN D. BRANDT, Safety and Security Branch Office of the Chief of Ordnance, Chicago, discussed "Industrial Ventilation," at the meeting held in Detroit. MAJOR BRANDT showed why some exhaust systems may fail to operate satisfactorily, and what methods should be adopted for making industrial ventilation effective.

At Grand Rapids on February 29, 1944, DR. C. O. SAPPINGTON, Industrial Health Consultant, Chicago, presented the subject "The Meaning of Industrial Medicine, Hygiene and Health." This meeting was held jointly with the Greater Grand Rapids Safety Council. In outlining the meaning of these three phases of industrial health, DR. SAPPINGTON pointed out the necessity for cooperation of safety engineer, nurse, industrial hygiene engineer, physician, labor and management.